DESCRIPTION

HIGH POWER LITHIUM UNIT CELL AND HIGH POWER LITHIUM BATTERY PACK HAVING THE SAME

Cross Reference to Related Application

This application is the national phase under 35 U.S.C. §371 of PCT International Application No. PCT/KR05/04454 and Korean Application No. 10-2004-0110550 are incorporated by reference herein in their entirety.

Technical Field

The present invention relates, in general, to a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell and, more particularly, to a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which increases the width of an electrode terminal of a lithium battery, thus reducing heat generation and a potential drop due to the resistance of the electrode terminal, and efficiently eliminating generated heat.

Background Art

A secondary battery is called a rechargeable battery, unlike a primary battery which is not rechargeable. The secondary battery has been widely used in high-technology electronic equipment, such as cellular phones, notebook computers, or camcorders.

Particularly, the operating voltage of a lithium battery is 3.6V, and is 3 times as much as a nickel-cadmium battery or a nickel-hydrogen battery, which are widely used as power sources for electronic equipment. Further, the lithium battery has high energy density per unit weight. For these reasons, the lithium battery has progressed rapidly.

Such a lithium battery uses a lithium-based oxide as the active material of cathode, and a

carbon material as the active material of anode. Generally, the lithium battery is classified into a liquid electrolyte battery and a polymer electrolyte battery. A battery using a liquid electrolyte is referred to as a lithium ion battery, and a battery using a polymer electrolyte is referred to as a lithium polymer battery. Since the lithium polymer battery, recently gaining popularity, is made of a flexible material, the shape of the battery may be variously changed. Further, the lithium polymer battery is excellent in stability and is light in weight, so that it is advantageous when necessary to achieve slim and lightweight portable electronic equipment.

Meanwhile, the lithium battery is variously manufactured, depending on the shape of a case which holds an electrode assembly. The lithium battery may have a cylindrical shape, a square shape, a pouch shape, etc. Generally, a cylindrical lithium battery uses a cylindrical aluminum housing, a square lithium battery uses a square aluminum housing, and a pouch-shaped battery uses a pouch housing made of a thin plate.

FIG. 1 is a perspective view of a conventional lithium unit cell, and schematically shows a body of the square lithium unit cell. FIG. 2 is a photograph showing the overheat state of the conventional lithium unit cell, after a lithium battery has discharged the current of about 30A.

As shown in FIG. 1, the body 11 of the conventional lithium unit cell includes a cathode plate 12, an anode plate 13, and a separator 14. The cathode plate 12 comprises a cathode collector coated with the active material layer of cathode. The anode plate 13 comprises an anode collector coated with the active material layer of anode. The separator 14 is inserted between the cathode plate 12 and the anode plate 13. After the cathode plate 12, the separator 14, and the anode plate 13 are sequentially arranged, they are wound and compressed, so that the body 11 of the conventional lithium unit cell is completed.

In this case, the cathode plate 12 and the anode plate 13 are welded to cathode terminal 15 and an anode terminal 16, respectively, so that they are exposed to the outside of the body 11. In this case, the cathode terminal 15 is made of nickel, and the anode terminal 16 is made of

aluminum.

Both the cathode terminal 15 and the anode terminal 16 are surrounded with protective tape 17 so as to prevent the portions exposed from the body 11 from being damaged.

Afterwards, the aforementioned body 11 is inserted into and assembled with a square aluminum housing, so that the lithium unit cell is obtained.

Currently, the lithium battery has been developed to have a high capacity of energy so as to be used for a lengthy period of time with only a single charging operation. However, a hybrid car requires a battery which is far smaller and lighter than that of an electric car and has a high momentary output. That is, since if the hybrid car needs energy, an engine may provide energy, the hybrid car does not need a large capacity of battery. Thus, the battery of the hybrid car emits stored energy for just several minutes or seconds, thus supplying power to the car, and must be capable of being recharged within a short period of time.

However, when the battery outputs high energy and is then recharged, a large quantity of heat is generated. Unless the heat is suppressed, the capacity and life-span of the battery may be reduced, and the battery may be broken or damaged.

When a high power battery is used, such as a battery for a hybrid car, charging and discharging speed of which is several times faster than that of the conventional lithium unit cell, a great deal of current flows in both the cathode terminal 15 and the anode terminal 16 which are exposed to the outside of the body 11.

Thus, as shown in FIG. 2, the conventional lithium battery 10 is problematic in that heat generation is concentrated around the cathode terminal 15 and the anode terminal 16, due to the resistance of the narrow cathode terminal 15 and anode terminal 16, so that the battery may be overheated to about 45°C or higher and a potential drop may occur.

Further, the conventional lithium battery 10 is problematic in that electrochemical reaction of the lithium battery 10 is concentrated on a place near the cathode terminal 15 and anode

terminal 16, so that heat is locally generated, and thereby, the lithium battery 10 is locally aged, thus shortening the life-span of the lithium battery 10 and causing damage to the battery, therefore leading to the possibility of fire or an explosion.

Disclosure of Invention

Technical Problem

Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which reduce the resistance of the battery, thus reducing the loss of energy, for example, heat generation and a potential drop that occur during a high power charging operation or discharging operation.

Another object of the present invention is to provide a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which prevent an electrochemical reaction from being concentrated on a portion near a cathode terminal and an anode terminal of a lithium battery when a charging or discharging operation is conducted at a high speed, thus allowing an electrochemical reaction to be uniformly performed throughout both the cathode and anode.

A further object of the present invention is to provide a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which prevent damage and leakage of a lithium battery due to the volume expansion of the battery when the battery is recharged or discharged.

A still further object of the present invention is to provide a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which efficiently disperse cool heat generated during a high power charging or discharging operation, and efficiently heat a low-temperature battery to an optimal temperature range.

Technical Solution

In order to accomplish the object, the present invention provides a high power lithium unit cell, including at least one rectangular cathode plate having a cathode collector, at least one surface of the cathode collector being coated with an active material of cathode; at least one rectangular anode plate having an anode collector, at least one surface of the anode collector being coated with an active material of anode; at least one separation film inserted between the rectangular cathode plate and the rectangular anode plate, and providing electric insulation; a cathode terminal connected to a cathode plate connecting part which protrudes from either of two long sides of four sides of the rectangular cathode plate; and an anode terminal connected to an anode plate connecting part which protrudes from either of two long sides of four sides of the rectangular anode plate.

According to the preferred embodiment, the cathode terminal and the anode terminal protrude in opposite directions.

According to another preferred embodiment, the cathode terminal and the anode terminal protrude in the same direction.

Further, the present invention provides a high power lithium battery pack, including at least one high power lithium unit cell, including at least one rectangular cathode plate, separation film, and rectangular anode plate sequentially laminated, a cathode terminal extending outwards from either of two long sides of four sides of the rectangular cathode plate, and an anode terminal extending outwards from either of two long sides of four sides of the rectangular anode plate; at least two gaskets laminated on both surfaces of the high power lithium unit cell; and a pair of support plates laminated on the outermost gaskets at least.

Brief Description of the Drawings

FIG. 1 is a perspective view of a conventional lithium unit cell;

FIG. 2 is a photograph showing an overheated state of the conventional lithium unit cell;

FIG. 3 is an exploded perspective view of a high power lithium unit cell, according to the first embodiment of the present invention;

FIG. 4 is a perspective view of the high power lithium unit cell, according to the first embodiment of the present invention;

FIG. 5 is an exploded perspective view of a high power lithium battery pack having a high power lithium unit cell, according to the second embodiment of the present invention;

FIG. 6 is a perspective view of the high power lithium battery pack having the high power lithium unit cell, according to the second embodiment of the present invention;

FIG. 7 is a perspective view showing a cooling method for the high power lithium battery pack having the high power lithium unit cell, according to the second embodiment of the present invention; and

FIG. 8 is a perspective view of a high power lithium unit cell, according to the third embodiment of the present invention.

Best Mode for Carrying Out the Invention

Hereinafter, a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, according to the present invention, will be described in detail.

FIG. 3 is an exploded perspective view of a high power lithium unit cell, according to the first embodiment of the present invention, and FIG. 4 is a perspective view of the high power lithium unit cell, according to the first embodiment of the present invention.

Referring to FIGS. 3 and 4, a high power lithium unit cell 100 according to the first embodiment of this invention includes cathode plates 110-1, ..., 110-A, anode plates 120-1, ..., 120-B, separation films 130-1, ..., 130-C, cathode plate connecting parts 111-1, ..., 111-A, anode plate connecting parts 121-1, ..., 121-B, a cathode terminal 140, and an anode terminal 150. In the

high power lithium unit cell 100 according to the first embodiment of this invention, the cathode plate connecting parts 111-1, ..., 111-A, and the anode plate connecting parts 121-1, ..., 121-B are directly connected to the cathode terminal 140 and the anode terminal 150, respectively. The cathode terminal 140 and the anode terminal 150 are exposed to the outside, and are surrounded with a predetermined packing material.

Each of the cathode plate 110-1, ..., 110-A is provided with a cathode collector which comprises a rectangular metal thin plate. The cathode collector may be made of an aluminum thin plate. At least one surface of the cathode collector is coated with the active material of cathode. The active material of cathode may comprise a mixture consisting of a lithium-based oxide which is a main element, a binder, a plasticizer, a conductive material, etc.

Each of the anode plate 120-1, ..., 120-B is provided with an anode collector which comprises a rectangular metal thin plate. The anode collector may be made of a copper thin plate. At least one surface of the anode collector is coated with the active material of anode. The active material of anode may comprise a mixture consisting of a carbon material which is a main element, a binder, a plasticizer, a conductive material, etc.

The separation films 130-1, ..., 130-C are inserted between the cathode plates 110-1, ..., 110-A and the anode plates 120-1, ..., 120-B, thus serving to electrically insulate the cathode plates and the anode plates from each other.

Each of the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B extends outwards from a long side of four sides of each of the cathode plates 110-1, ..., 110-A and the anode plates 120-1, ..., 120-B. In this case, each of the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B is about 1/5 ~ 1 times as wide as a long side of each of the rectangular cathode plates 110-1, ..., 110-A and the rectangular anode plates 120-1, ..., 120-B.

The cathode terminal 140 is attached to the cathode plate connecting parts 111-1, ..., 111-

A which are exposed to the outside, thus forming one electrode.

Similarly, the anode terminal 150 is attached to the anode plate connecting parts 121-1, ..., 121-B, thus forming one electrode.

According to the preferred embodiment, the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B may be connected to the cathode terminal 140 and the anode terminal 150, respectively, by welding the cathode plate connecting parts 111-1, ..., 111-A to the cathode terminal 140 and welding the anode plate connecting parts 121-1, ..., 121-B to the anode terminal 150.

According to another preferred embodiment, the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B may be connected to the cathode terminal 140 and the anode terminal 150, respectively, by applying a highly conductive material to the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B and thereafter compressing the cathode plate connecting parts and the anode plate connecting parts, coated with the highly conductive material, against the cathode terminal 140 and the anode terminal 150, respectively. Further, they may be connected to each other using an adhesive containing a highly conductive material. In this case, the highly conductive material for coating or adhesion may be selected from the group consisting of gold, carbon nanotube, etc.

Meanwhile, a conductor, such as the electrode terminal, including the cathode terminal 140 and the anode terminal 150 of the high power lithium unit cell 100, has a resistance and a heat quantity which are calculated according to the following equations 1 and 2.

【Equation 1】

$$(resis\tan ce) = (specificresis\tan ce) \times \frac{(lengthofconductor)}{(sectionalareaofconductor)} -$$

【Equation 2】

$$(heatquantityofconductor) \propto (current)^2 \times (resistance)$$

As shown in the equations 1 and 2, the high power lithium unit cell 100 according to this invention has the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B on two long sides of a rectangle. Thus, the sectional areas of the electrode terminals 140 and 150, the cathode plate connecting parts 111-1, ..., 111-A, and the anode plate connecting parts 121-1, ..., 121-B are increased, and the length of the electrode terminals 140 and 150 is reduced, in comparison with the conventional lithium unit cell 10 shown in FIG. 1. Thus, when the same quantity of current flows during a charging or discharging operation, the quantity of generated heat is dramatically reduced.

Therefore, when the high power lithium unit cell 100 according to this invention is used in a high power battery, such as a hybrid car battery, the quantity of generated heat is small, and the loss of energy, such as a potential drop, is reduced, compared to the conventional lithium unit cell 10 of FIG. 1.

Further, the high power lithium unit cell 100 according to this invention is constructed so that the cathode plate connecting parts 111-1, ..., 111-A and the anode plate connecting parts 121-1, ..., 121-B are connected to the cathode terminal 140 and the anode terminal 150, respectively. Thus, when the high power lithium unit cell of this invention is recharged or discharged at a high speed, a local electrochemical reaction is reduced in comparison with the conventional lithium unit cell 10 of FIG. 1. Thereby, the electrochemical reaction is uniformly performed in respective layers and parts of the battery.

According to the preferred embodiment of this invention, the high power lithium battery may be a simple structure obtained by arranging the separation film 130-1, the cathode plate 110-1, the separation film 130-2, the anode plate 120-1, and the separation film 130-3 in layers. Preferably, the high power lithium battery may have a multi-layered structure obtained by sequentially laminating several cathode plates, anode plates, and separation films.

Further, the cathode plates 110-1, ..., 110-A, the anode plates 120-1, ..., 120-B, and the separation films 130-1, ..., 130-C may be connected to each other in the form of one film, that is, a winding form or a jelly roll form. Further, they may be separated from each other in a stacking form.

FIG. 5 is an exploded perspective view of a high power lithium battery pack having a high power lithium unit cell, according to the second embodiment of the present invention, FIG. 6 is a perspective view of the high power lithium battery pack having the high power lithium unit cell, according to the second embodiment of the present invention, and FIG. 7 is a perspective view showing a cooling method for the high power lithium battery pack having the high power lithium unit cell, according to the second embodiment of the present invention.

Referring to FIGS. 5 and 6, a high power lithium battery pack 1000 having a high power lithium unit cell, according to the second embodiment of the present invention, include high power lithium unit cells 100-1, ..., 100-D, gaskets 200-1, ..., 200-E, and support plates 300-1, ..., 300-F.

The high power lithium unit cells 100-1, ..., 100-D include cathode plates, anode plates, separation films, cathode plate connecting parts, anode plate connecting parts, cathode terminals 140-1, ..., 140-D, and anode terminals 150-1, ..., 150-D, as shown in FIGS. 3 and 4.

According to the preferred embodiment, the high power lithium unit cells 100-1, ..., 100-D are connected to each other in series by connecting the cathode terminal of one unit cell to the anode terminal of a neighboring unit cell or by connecting the anode terminal of one unit cell to the cathode terminal of a neighboring unit cell. Such a series connection may be applied to a high voltage-high power battery of a hybrid car or the like.

The gaskets 200-1, ..., 200-E are laminated on both surfaces of each high power lithium unit cell 100-1, ..., 100-D to be installed between the high power lithium unit cells 100-1, ..., 100-D. The gaskets 200-1, ..., 200-E firmly maintain the high power lithium unit cells 100-1, ..., 100-D during a charging or discharging operation, thus absorbing vibration and shocks, and preventing

leakage due to volume expansion.

Typically, when the cathode terminals 140-1, ..., 140-D and the anode terminals 150-1, ..., 150-D exposed to the outside of the high power lithium unit cells 100-1, ..., 100-D are wide, contacting area between the electrode terminals 140-1, ..., 140-D and 150-1, ..., 150-D and a packing material is increased. Thus, the possibility of leakage may increase due to volume expansion, and the permeation of water may occur.

However, the high power lithium battery pack 1000 according to this invention firmly keeps weak portions airtight, using the gaskets 200-1, ..., 200-E, thus preventing leakage or water permeation.

Further, when the high power lithium battery pack 1000 according to this invention is used, the gaskets 200-1, ..., 200-E, serving as a component of a car, absorb shock and vibration, thus improving durability and vibration resisting capability, therefore increasing the life-span and durability of the high power lithium unit cells 100-1, ..., 100-D under vibration conditions similar to those of a car.

The support plates 300-1, ..., 300-F are attached to both surfaces of one of the high power lithium unit cells 100-1, ..., 100-D or are attached between the laminated high power lithium unit cells 100-1, ..., 100-D. Further, the support plates 300-1, ..., 300-F may be inserted between the gaskets 200-1, ..., 200-E disposed on both surfaces of neighboring high power lithium unit cells 100-1, ..., 100-D. The support plates 300-1, ..., 300-F serve to enhance the cooling effect of the high power lithium unit cells 100-1, ..., 100-D, and support the high power lithium unit cells 100-1, ..., 100-D and the gaskets 200-1, ..., 200-E so as to prevent them from being deformed.

Preferably, the support plates 300-1, ..., 300-F are made of a conductive material so as to radiate heat generated by the high power lithium unit cells 100-1, ..., 100-D to the outside. Further, the support plates 300-1, ..., 300-F may protrude outwards from the gaskets 200-1, ..., 200-E so as to provide the same cooling effect as the electrode terminals 140-1, ..., 140-D and 150-1, ...,

150-D.

As shown in FIG. 7, heat generated in the high power lithium battery pack 1000 having the high power lithium unit cell according to this invention is uniformly cooled in all of the high power lithium unit cells 100-1, ..., 100-D by passing cool air through space defined between the cathode terminals 140-1, ..., 140-D and the anode terminals 150-1, ..., 150-D, which protrude outwards from the gaskets 200-1, ..., 200-E.

Conversely, when the temperature of the high power lithium battery pack 1000 having the high power lithium unit cell according to this invention is excessively low and the performance of the high power lithium battery pack is thus deteriorated, hot air passes through the space defined between the cathode terminals 140-1, ..., 140-D and the anode terminals 150-1, ..., 150-D. Thereby, all of the high power lithium unit cells 100-1, ..., 100-D may be heated to a suitable temperature.

Meanwhile, when the support plates 300-1, ..., 300-F protruding out of the gaskets 200-1, ..., 200-E are provided, the protruding parts of the cathode terminals 140-1, ..., 140-D, the anode terminals 150-1, ..., 150-D, and the support plates 300-1, ..., 300-F may be cooled or heated.

Thus, the high power lithium battery pack 1000 having the high power lithium unit cell, according to the present invention, is provided with the wide cathode terminals 140-1, ..., 140-D and anode terminals 150-1, ..., 150-D, so that heat transmission speed is faster in comparison with the prior art, thus achieving a high heat-removal effect.

As described above, the high power lithium battery pack 1000 having the high power lithium unit cell, according to the present invention, cools or heats the protruding parts of the cathode terminals 140-1, ..., 140-D, the anode terminals 150-1, ..., 150-D, and the support plates 300-1, ..., 300-F, thus maintaining the temperature of the high power lithium unit cells 100-1, ..., 100-D to be -20□ to 50□, and preferably, 0□ to 40□.

FIG. 8 is a perspective view of a high power lithium unit cell, according to the third

embodiment of the present invention.

As shown in FIG. 8, the high power lithium unit cell according to the third embodiment of this invention includes cathode plates 410-1, ..., 410-F, anode plates 420-1, ..., 420-G, separation films 430-1, ..., 430-H, cathode plate connecting parts 411-1, ..., 411-F, anode plate connecting parts 421-1, ..., 421-G, an cathode terminal 440, and a anode terminal 450, similar to the first embodiment.

When comparing the high power lithium unit cell 100 according to the first embodiment shown in FIGS. 3 and 4 with the high power lithium unit cell 400 according to the third embodiment shown in FIG. 8, the high power lithium unit cell 100 according to the first embodiment is constructed so that the cathode terminal 140 and the anode terminal 150 extend in opposite directions from two long sides of four sides of a rectangle. However, the high power lithium unit cell 400 according to the third embodiment is constructed so that the cathode terminal 440 and the anode terminal 450 extend outwards from either of two long sides of a rectangle in such a way as to be spaced apart from each other. In this case, each of the cathode and anode terminals 440 and 450 of the high power lithium unit cell 400 has a width of about 1/8 ~ 1/2 of a long side of the rectangle.

As such, the high power lithium unit cell 400, according to the third embodiment of this invention, is constructed so that the cathode and anode terminals 440 and 450 extend outwards from a long side of the rectangle, the sectional area of each electrode terminal 440, 450 is larger than that of the conventional lithium unit cell of FIG. 1.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Industrial Applicability

As described above, the present invention provides a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, constructed so that an electrode terminal is provided on a long side of the rectangular unit cell, thus increasing the width of the electrode terminal, thereby reducing heat generation and a potential drop due to the resistance of the electrode terminal during a high power charging or discharging operation. Therefore, the life-span of the battery is prolonged, in addition to reducing the loss of energy.

Further, the present invention provides a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, constructed so that an electrode terminal is directly connected to an electrode layer, thus reducing resistance and thereby reducing the quantity of generated heat. Hence, a localized electrochemical reaction occurring at a position near an electrode terminal of a conventional battery is reduced, and thus it is possible to evenly use respective electrode layers.

Further, the present invention provides a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, which use a wide electrode terminal, thus allowing heat generated in the electrode terminal from being discharged to the outside within a short period of time, and allowing the battery to be heated to a suitable temperature within a short period of time when the temperature of the battery is low.

The present invention provides a high power lithium unit cell and a high power lithium battery pack having the high power lithium unit cell, constructed so that gaskets are laminated on both surfaces of the unit cell, thus preventing leakage or water permeation at a junction of the electrode terminal and a packing material due to volume expansion during a charging or discharging operation, and absorbing shocks and vibration, therefore increasing durability and life-span thereof.

The present invention provides a high power lithium unit cell and a high power lithium

battery pack having the high power lithium unit cell, constructed so that cathode and anode terminals protruding outwards from gaskets have wide heat transmission areas, thus controlling a cooling or heating operation, required for maintaining a proper temperature so as to ensure optimal performance of the battery, within a very short period of time.